Start-Up Results and Next Steps for the Commercial NOxOUT® System At a 600 MWe Coal Fired Electric Utility Unit

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In 1999 Fuel Tech, Inc. (FTI) completed start-up of a commercial NOxOUT® system for NOx reduction at a coal fired electric power utility unit on the East Coast. The unit is a supercritical Foster Wheeler opposed wall fired unit burning bituminous coal and/or natural gas with a nominal rating of 575 MWe net. The system was tuned for operation with firing rates corresponding to gross power generation of up to 610 MWe. The NOxOUT® selective non-catalyic reduction (SNCR) system was designed as the first step in NOx reduction using simple wall injectors.

At present, NOxOUT® has been applied in 30 applications larger than 100 MWe. NOxOUT® is the technology for applying urea based selective non-catalytic reduction (SNCR) for NOx reduction. Fuel Tech has applied this product to more than 200 units world-wide with commercial operations ranging from small fire-tube package boilers to utility electric steam generators producing more than 600 MWe.

Modular construction was used to expedite installation. Substantial pre-assembly of equipment systems was utilized. Equipment rooms were prefabricated and shipped as units. These contained the pumping, chemical distribution, and local control equipment. The wall injectors were designed for high momentum to enable effective coverage in the large furnace. The equipment arrived on-site late in the fall of 1998. Start-up testing began in March 1999.

Established commercial design procedures and methods were utilized. FT's design systems include computational fluid dynamics (CFD), chemical kinetics (CKM), and injection simulation modeling. These tools provided the analytical basis for estimating performance. Field measurements were made to obtain data for validating the CFD models. Temperature profiles in the unit were mapped with multiple high velocity thermocouple (MHVT) equipment. The current system was designed to achieve NOx reductions of 25% at full load. At low load, reductions of 35% on coal and 30% on gas were guaranteed. The guarantees were based on extensive modeling and evaluation of the unit.

The performance achieved contract guarantee requirements. Baseline NOx emissions varied greatly with various firing combinations, covering a range from 0.3 to 0.7 lb/10^6 Btu. NOx was controlled to below 0.35 lb/10^6 Btu on coal and 0.28 lb/10^6 Btu firing natural gas. Acceptance tests were performed in July 1999 at high and low loads. NOx was reduced from 0.45 lb/10^6 Btu to 0.33 lb/10^6 Btu at high load. At 150 MWn output, NOx was reduced to below 0.35 lb/10^6 Btu from a baseline of 0.62 lb/10^6 Btu. Ammonia slip was controlled to less than 5 ppm. Operation in automatic control was maintained.

Achievable performance has been identified for future steps to increase NOx reduction. Provisions were made for water-cooled multi-nozzle injection lances to extend treatment to cooler regions in the unit. Hybridization with a small catalyst (SNCR/SCR) is an option. Conversion of the SNCR system to amine enhanced fuel lean gas reburn (AEFLGR™) was identified. Commercial guarantees for the various steps were defined.

AEFLGR™ is another option in post combustion NOx reduction technologies. It provides a synergistic combination of the Fuel Lean Gas Reburn (FLGR™) and NOxOUT® technologies. FLGR™ is licensed from the Gas Research Institute (GRI). The injection of amine enhanced natural gas in the proper temperature window results in chemical reactions that reduce NO to molecular nitrogen within this window. The process relies on using controlled velocity turbulent jets for dispersing the chemical additives in the furnace. The amount of natural gas is controlled so as to maintain an overall fuel lean stoichiometry in the upper furnace. The chemical kinetic mechanisms of FLGR™ and SNCR have similar selective reactions. The injection of natural gas in hot, low oxygen furnace gas results in the formation of hydrocarbon radicals (CH_i), and the injection of urea (NH_2-CO-NH_2) results in the formation of amine radicals (NH_i). Both of these radicals reduce NO to molecular nitrogen reactions. In very simplified terms (unbalanced):

$$CH_4 + NO \rightarrow \Sigma CH_i + NO \rightarrow HCN + NO \rightarrow N_2 + \ldots.$$

$$NH_2CONH_2 + NO + O_2 \rightarrow NH_i + NO + CO + O_2 \rightarrow N_2 + CO_2 + H_2O$$

Design engineering for applying AEFLGR™ to the unit has begun. New models of the unit have examined the effectiveness of gas jets for penetrating the flue gas. Regions of high NOx and reduced oxygen concentrations are ideally targeted for maximum effectiveness. Injector configurations are currently being examined. Visualization of the models in virtual reality facilitates optimization of the injection strategy.

The customer has elected to move forward with engineering for future AEFLGR™ capability exceeding 50% NOx reduction. An attractive feature of AEFLGR™ is its flexibility in meeting seasonal controls on emissions. The equipment facilitates operation with AEFLGR™ in the summer ozone season. During this time natural gas is normally available at normal prices. The system can switch to conventional SNCR in winter when demand on natural gas is high.